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ABSTRACT

In helping students to read materials in intermediate level science classes, teachers should first motivate them to read and should set a purpose and a focus for their reading. A postreading discussion should follow each reading task, in order to help students share, integrate, and apply insights obtained from the written materials. Books and reading should be used in concert with an activity-oriented inquiry program. Reading science materials involves such tasks as making measurements; reading graphs, maps, blueprints, star charts, diagrams, and pictures; and decoding symbolic statements. Each of these tasks requires specific skills, and instructional techniques may be devised to help students develop these skills. Students must have clear directions to follow so that they can work independently in examining, organizing, and analyzing data. Five factors that influence readability of directions are sentence structure, vocabulary, illustrations, sequencing, and readability of print. Finally, since teacher attitudes toward reading may influence students, teachers should assess their own attitudes; they should also attempt to improve student attitudes toward reading science materials. (GW)

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Improving the Reading of Visual Materials in Intermediate and Junior Secondary School Science

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The science curricula of the 1960's and the second generation curricula of the 1970's are attempts to put science instruction on an acitivity orientation, thus decreasing the amount of reading about science in favor of doing science. Regardless of how optimistic one may have been, sales records indicate that the 1960 curricula were less than a total success. Curricula like ESS, SCIS, and SAPA captured less than 10 percent of the elementary school market, leaving the remainder for textbook science programs. The reasons for the high resistance to the activity-oriented programs are multi-faceted and not of major interest at this time. The main theses of this paper are to explore teaching strategies, specific skills, and problems unique to effective science reading in the middle grades.

Teaching Strategy

The organization of science instruction utilizing print materials should attempt to reflect science inquiry while developing motivation, problem focus, experience, and closure. A three-phase approach of introduction, reading, and post-reading discussion has been successful. The introduction should consider similar purposes as the activity-oriented pre-lab (Yore, 1976). Vacca (1977) states:

> The goal of readiness to read in content areas presumes that students will be mentally and

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> psychologically prepared to begin a reading assignment - in a state of mind which will promote learning.

Fredericks (1968) suggested:

> Pre-learning experience can be used to advantage in readiness if experiences: 1) lead to a concept, 2) are relevant to the concept, and 3) provide a direction in learning the concept.

Teachers can establish the cognitive itch, otherwise known as motivation and problem focus, by capitalizing on chance occurrences, discrepant events, exotic demonstrations, jokes, and games appropriate to the learners and topic under consideration (Yore, 1976). The motivation device should surface unique problems that can be solved by reading the textual materials as well as providing embryonic insight and background of the phenomena. Newspaper articles on forthcoming meteorite showers are reasonable stimuli for reading about astronomy. Optical illusions can effectively introduce readings on the eye; an ammonium dichromate reaction stirs curiosity about volcanoes, while B.C. cartoons are appropriate to a wide variety of topics (Yore, 1975).

Outlining the critical student-initiated questions on the chalkboard will help reinforce the major ideas to be discovered, thus providing purpose and focus for the resultant reading. Cautions should be taken to introduce reasonable amounts of textual materials. It may be worthwhile to order student-initiated questions in a manner that mirrors the organization of the textual material. This will allow the teacher to portion the textual assignment into approximately-sized pieces.

The reading task replaces the laboratory phase of an inquiry lesson. Reading is the process by which the students collect data from which they will later formulate solutions to the focus problems. As is the case when observing and measuring in inquiry laboratories, many students leave the reading task with

unsynthesized bits of data. This occurs to a lesser degree in well-organized and readable textbooks.

The post-reading discussion of the focus questions should attempt to get students to share, integrate, synthesize, and apply insights obtained from the written materials. Organizing teacher-directed questions to get students to recall, translate, and synthesize the knowledge fragments will help students to comprehend the science concepts and minimize the negative effects of poor reading. Special consideration may be needed so that the children's inability to read does not prevent them from doing the necessary thinking (Durrell, 1975). The logically-structured oral discussion will allow the less able reader to experience a developmental logic of science and inquiry. The closing application level questions will help associate the newly-acquired knowledge with realistic uses and will improve retrieval of the knowledge at a later time. Applications should explore situations not defined in the textual materials, but related to the students' reality.

The development of a bibliography of books, articles, pamphlets, and student reports (Harp, 1977) related to the topic and with a wide range of readability can provide an open-ended component for interested students. The Curriculum Library, University of Victoria (Roland & Hamilton, 1977), has developed such a list of related references for topics in many of the ESS, EYE, Science 5/3, and TPS units. Criscuoli (1977) provided a method for collecting high interest books and a list of such books on life science.

Teaching science exclusively by the use of reading is a questionable practice, as it creates an image of science which is faulty -- namely, that science is a noun rather than a verb, a body of knowledge committed to print rather than an ongoing process of human creativity. Books and reading are part of the organization of science knowledge, but should be used in concert with the activity-oriented

inquiry programs.

Science Reading Skills and Problems

An analysis of textual science materials reveals that certain specific reading and reading-related skills are common and deserve special attention. Cassidy (1977), in a Right to Read funded project, Content Area Reading Enrichment (CARE), found that reading science material required the ability to decode (1) cause-and-effect statements, (2) directions (step-by-step list and narrative forms), and (3) Latin and Greek root words. Specific instructional activities regarding these skills are available from CARE. Knight and Hargis (1977) suggested specific instructions in decoding word problems and symbolic language in mathematics are needed. Since mathematics and science are normally intertwined, these skills are also needed for effective science reading.

Science textual materials and activities also include other reading-like tasks, such as making measurements; reading graphs, maps, blueprints, star charts, diagrams, and pictures; and decoding symbolic statements. Reading measurements from metric scales and various meters produce unique difficulties that require specific instruction. Each apparatus has unique limitations as well as observer error. Apparatus error is at least $\pm$ one-half the smallest calibration on the instrument; therefore, no exact measurements are possible. Inexpensive apparatus generally exceeds even these minimal limits. Observers should be instructed to avoid parallax (apparent displacement due to difference between two points of view) and to take several readings, resulting in an average measurement. Parallax can be limited by getting students to place their heads consistently and directly over the scale or dials. Getting students to make average measurements minimizes apparatus error as well as canceling some of the indeterminate observer errors.

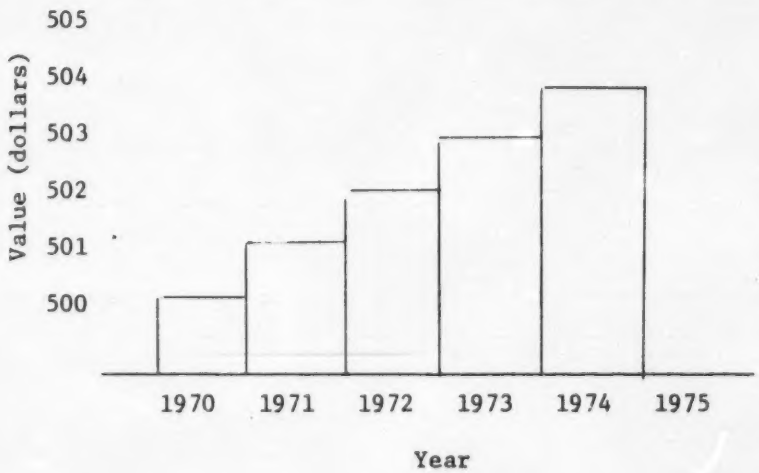
Reading graphs contains specific pitfalls, and students need to be exposed

to these pitfalls under controlled circumstances. Since the horizontal and vertical axes need not use the same scale, students can be confused unless they have previously encountered such situations. Also, since each point on a flat surface represents two pieces of data, students need to have practice with such an experience prior to reading graphs and maps. Games like Battleship (Milton-Bradley) provide children with practice of this prerequisite skill. One of the most common misconceptions in reading graphs results from using non-continuous scales on the horizontal or vertical axes. Figure 1 illustrates a common type of graph related to the mass media. Notice at first glance it is possible to infer that the growth is greater than it is. Closer investigation and specific consideration of the values on the vertical scale illustrate that the growth, in relative terms, is much less than originally inferred. Students need to experience this problem to realize the value of checking the scale on the axes before jumping to conclusions.

Figure 1

Misleading Graphs

Stock Price for Simple-minded Enterprises

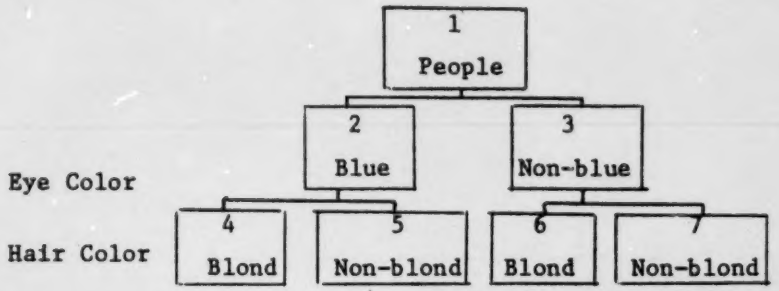


Science textbooks contain a large amount of flat graphic material in the form of maps, blueprints, and star charts. All of these materials are attempts to represent real space in a non-realistic manner, and special training is needed to develop the appropriate reading skills. Students need to realize that they must attend to ledger, scale, and spatial orientation before much information can be gleaned from the material. Reading contour maps illustrates the unique information that can be obtained from print material. Properly interpreted, the flat print material produces a mental image of a three-dimensional space. The correctness of the image depends on how well the reader decoded the closeness of contour lines and V's in the lines. Mapping Small Places (EYE, 1972) provides excellent activities directed toward these skills. Reading star charts illustrates the spatial orientation problem related with some science materials. Adequate interpretation of star charts requires the reader to vertically and/or horizontally rotate his mental image to correspond with reality. Initially it may be necessary to physically orient the reader in such a way to simplify the spatial translation. This can be done by having Polaris (North Star) on the star chart pointing north while the reader holds the star chart above his head. Such a physical orientation corrects the directional orientation problem and only requires that the reader linearly extend the charted positions to the approximate real positions.

Reading diagrams in science material is likely an art, not a science, for many science illustrators belong in the surrealistic movement. Students must realize that some freedom in interpreting diagrams of apparatus setups and other equipment is possible. Diagrams representing classification keys are simplified once the reader realizes that reading down the diagram is equivalent to the intersection or compounding of the attributes. Figure 2 illustrates a people key for classifying humans by commonly observed attributes.

Figure 2

Classification Keys for People



Therefore, any people in space 2 have blue eyes and may have a wide variety of other characteristics. Space 4 is reserved for people with blue eyes and blond hair.

One way of helping students read pictures is to develop the concepts of foreground, background, and, if possible, middleground. An effective way to develop these concepts is by field-sketching. Students are taken to the area to be sketched, taught to hold their paper vertically so the area to be sketched appears at the top of the paper, and asked to draw a horizon line near the top of the paper. Students quickly learn that objects near the bottom of the paper are in the foreground, objects near the top of the paper are in the background, while objects near the middle are in the middleground (Cross, 1976). The concepts related to interpreting pictorial data should next be applied to specific cases in science textbooks.

Decoding symbolic statements in science is basically a problem of vocabulary and knowing the meaning of the symbols, such as:

$$\vec{f} = \vec{ma}$$

If a student reads the above formula as "f arrow double line m a arrow", it is likely that he does not understand the meaning of the formula. Comprehension

is likely better if students are encouraged to read symbolic statements in terms of their actual meaning, rather than what is printed. Therefore, the short formula found above becomes: "The vector quantity force is equal to the product of the scalar quantity mass times the vector quantity acceleration." This example points out that the readability and length of textual science material cannot be assessed at face value or number of pages. The teacher must be sure that length of reading assignments reflects the difficulty and variation of materials included.

One of the inquiry program goals is to have students develop science content, processes, and affect by independently examining, organizing, and analyzing data. In order to successfully complete independent activities, students must have clear directions to follow. Pikulski and Jones (1977) have identified five factors which influence readability of directions. Direction writers should attempt to use familiar sentence patterns. The easiest sentence pattern to understand is subject-verb-object, so simple declarative sentences should be used when possible. The use of pronouns should be minimized, since pronouns may be difficult to interpret as children have difficulty identifying and remembering pronoun referents.

Vocabulary is the second factor. Concept words, such as chemical, magnetic or corpuscle, may need to be introduced by the teacher before students are expected to complete independent activities (experiments or readings). Terms such as estimate, determine or control may need to be replaced by the more common student vernacular, i.e., guess, find out or keep constant. Difficult vocabulary turns student-centered explorations into teacher-dependent activities.

The third factor is illustrations. When pictures illustrate difficult concepts, the reading difficulty is reduced. A complex operation may sometimes be illustrated by a picture sequence which makes the sequence much easier to follow. Students frequently forget to look at illustrations, so a simple statement

like, "Look at the picture," is helpful in the directions at the appropriate place.

The fourth factor is the order of directions. Numbering each step is advisable. Statements such as "Do number two after number one" are more difficult thatn "Do number one and then do number two."

The last factor is typography. Small and/or crowded print is much more difficult to read than large, well-spaced print. Do not be afraid to leave generous margins. Color-coding and underlining add emphasis when used sparingly.

Easy-to-read directions are characterized by (1) familiar sentence structures, (2) familiar vocabulary, (3) illustrations, (4) careful sequencing, and (5) readable print.

A final hint to science teachers regarding reading was supplied by Manning (1972) which was that the value placed on reading by parents was the major factor affecting the children's reading achievement. Rieck (1977) extended Manning's ideas to content teachers and found that most teachers assign reading, but their students do not read the assigned material because teachers do not provide purpose or follow-up and are perceived as being indifferent to reading. Rieck believes "teachers who do not read and who do not value reading may pass their limited concept of reading on to their students." Vaughan (1977) has developed a simple scale for assessing teacher attitude toward reading (see Appendix A) A first step for the content teachers might be a self-assessment of their attitudes. Second, Rieck (1977) suggested some steps to improve student attitudes toward reading science:

1. Model the reading act.
2. Encourage reading.
3. Share reading materials and ideas.
4. Provide a range of readability and topical materials.

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